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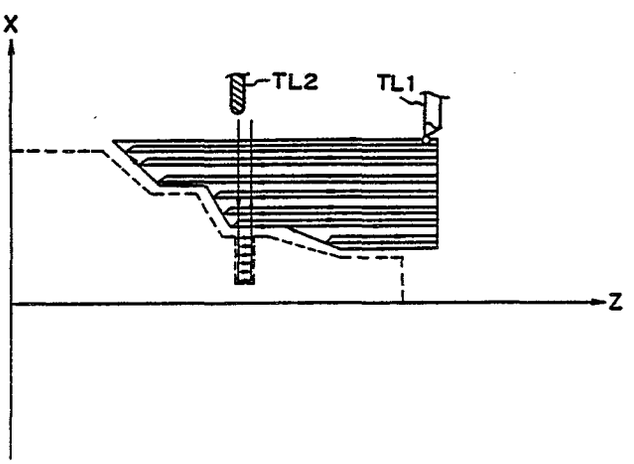
(54) NC programming apparatus.

(57) In creating an NC program for machining a workpiece by each of a plurality of tools (TL1, TL2) in respective quadrants, the paths traversed by each of the tools are displayed in one and the same quadrant on the basis of NC data in the process of being created, or on the basis of already existing NC data. By displaying the paths in the same quadrant it becomes easy to visualise the overall contour of the piece to be machined by the tools and whether NC programming is proceeding correctly.



EP 0 103 428 A2

NC PROGRAMMING APPARATUS

This invention relates to an NC programming apparatus. More particularly, the invention relates to an NC programming apparatus used in creating an NC program for machining a workpiece in separate quadrants by each of a plurality of tools, or in verifying an already created NC tape in which the NC program has been punched.

A lathe having four simultaneously controllable axes, referred to hereinafter simply as a "four-axis lathe", is equipped with two tool rests each of which is controlled independently to machine a workpiece. Such a lathe may come equipped with one or two spindles. Fig. 1 is an explanatory view of the foregoing lathe having one spindle. SP represents the spindle, WK a workpiece held and rotated by a chuck CHK, and TL1, TL2 first and second tool rests, respectively. With a four-axis lathe of this kind, the two tool rests TL1, TL2 subject the single workpiece WK to machining in first and fourth quadrants, respectively, enabling machining efficiency to be greately improved.

Since the tool rests TL1, TL2 are transported in the first and fourth quadrants, respectively, an NC program is created for moving the tool rest TL1 in the first quadrant, and another NC program is created for

moving the tool rest TL2 in the fourth quadrant. It has been attempted to display or plot the path of each tool on a CRT or plotter as the NC programs are being created, or in accordance with an already created NC tape in which the NC programs have been punched. Owing to the machining carried out in the separate quadrants, however, one tool path is displayed or plotted in the first quadrant and the other in the fourth quadrant, as shown in Fig. 2. (It should be noted that the dashed line in Fig. 2 is not displayed or plotted.) This makes it difficult to grasp the overall contour machined by the tools of the tool rests TL1, TL2, and it cannot be readily ascertained whether NC programming is proceeding correctly. In other words, with an automatic programming apparatus in which a workpiece is machined in separate quadrants by each of a plurality of tools, a problem confronted in the prior art is that the paths traversed by the tools cannot be displayed together in one and the same quadrant, making it difficult to comprehend correctly the final, overall shape and, hence, to check the programs.

An object of the present invention is to provide an NC programming apparatus wherein NC programming can be checked for correctness with ease by enabling observation of a machined shape in its entirety.

According to the present invention, the foregoing object is attained by providing an NC programming

apparatus for creating an NC program in accordance with which a workpiece is subjected to machining by each of a plurality of tools in respective quadrants. The paths traversed by the respective tools are displayed in one and the same quadrant to enable the overall final shape of the workpiece to be grasped correctly.

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

Fig. 1 is an explanatory view of a four-axis lathe having two tool rests each of which is controlled along two axes simultaneously;

Fig. 2 is an example of a display showing tool paths according to the prior art;

Figs. 3 and 4 are examples of displays showing tool paths according to the present invention; and

Figs. 5 and 6 are block diagrams showing first and second embodiments, respectively, of an automatic programming apparatus according to the present invention.

Reference will now be had to Figs. 3 and 4 showing examples of displays of tool paths according to the present invention. Both figures relate to the

four-axis lathe described above, the lathe having two tool rests TL1, TL2. Fig. 3 shows an example in which the paths traversed by the tools of the tool rests TL1, TL2 are displayed in the first quadrant for a case where a turning operation is performed in the first quadrant by the tool rest TL1 and a grooving operation is performed in the fourth quadrant by the tool rest TL2. Fig. 4 shows an example in which the paths traversed by the tools of the tool rests TL1, TL2 are displayed in the first quadrant for a case where coarse cutting is performed in the first quadrant by the tool rest TL1 and fine or finishing cutting is performed in the fourth quadrant by the tool rest TL2. It should be noted that the dashed line in Figs. 3 and 4 is not displayed.

Fig. 5 is a block diagram illustrating an embodiment of an automatic programming apparatus according to the present invention. A data input unit 101 such as a keyboard is provided for the entry of various data such as program data expressed by an automatic programming language. For further details, see the instruction manual "FANUC SYSTEM P-MODEL D FAPT TEACHER", June, 1980, published by Fujitsu Fanuc K.K. When the program data is entered, an NC data creation unit 102 creates NC data, which is then stored in a RAM 104, under the control of a control program for NC part program creation stored in a ROM 103. We will assume that the program data entered from the data input unit

101 are first and second program data (programs) for controlling first and second tool rests TL1, TL2 of a four-axis lathe, and that tool selection instructions have been inserted in each program at appropriate locations. Further, although the tools of the first and second tool rests actually machine a workpiece in the first and fourth quadrants, respectively, the first and second programs are created as programs for machining the workpiece in the first quadrant by the first and second tool rests. The reason for this will become apparent hereinbelow. A tool - quadrant memory 105 connected to the NC data creation unit 102 stores correspondence between tool codes and quadrants in which a workpiece is to be machined by the tools specified by the tool codes. The data input unit 101 is connected to a register 106 and is also used to enter data, which are set in the register 106, indicative of a quadrant (display quadrant) in which tool paths are to be displayed. In the illustrated embodiment, this quadrant is the first quadrant.

When the NC data creation unit 102 creates NC data and stores the data in the RAM 104, a display unit 107 displays the tool paths of the first and second tool rests, as shown in Fig. 3 or 4, based on the NC data stored in the RAM. At the same time, the NC data creation unit 102 reads the first and second tool rest quadrant data out of the tool - quadrant memory 105 and sets the data in a register 108. More specifically,

the quadrant data read out of the memory 105 and set in the register 108 is quadrant data corresponding to a tool code inserted in the first program data, and quadrant data corresponding to a tool code inserted in the second program data. When this has been carried out, the NC data creation unit 102 goes to the RAM 104 and successively reads out the NC data for the first tool rest and the NC data for the second tool rest from the beginning thereof, and applies the data to a sign converting unit 109. Since the working area of the first tool rest is the first quadrant, and since the display quadrant is also the first quadrant, the NC data for the first tool rest read out of the RAM 104 is delivered from the sign converting unit 109 without being subjected to a sign conversion by the converting unit 109. On the other hand, the working area of the second tool rest is the fourth quadrant while the display quadrant is the first quadrant. Therefore, the NC data for the second tool rest is delivered by the sign converting unit 109 after the sign of the direction of movement solely along the X axis is changed. The coordinate system is as shown in Figs. 3 and 4.

The NC data delivered as an output by the sign converting unit 109 is stored in a RAM 110 and applied to a tape puncher 111 where the data is punched into a paper tape 112 to create an NC tape.

Thus, programming using an automatic programming

language such as APT or FAPT is carried out as if a workpiece will be machined by each of the tools in the quadrant in which the tool paths are to be displayed. Then, based on the program data, NC data is created and the paths traversed by all tools are displayed in one and the same quadrant in accordance with the created NC data. Meanwhile, the NC data is subjected to a sign conversion in accordance with the quadrants in which machining is actually to be performed, and NC data is created using the NC data obtained by the sign conversion.

Instead of performing automatic programming for machining a workpiece in the quadrant in which the tool paths are to be displayed, as described above, it is possible to carry out programming using an automatic programming language in which the actual machining quadrants serve as a reference, and then change the sign of the NC data in accordance with the quadrant in which the tool paths are to be displayed. Such an embodiment will now be described with reference to Fig. 6.

Fig. 6 is a block diagram illustrating a second embodiment of the present invention, in which portions similar to those of the first embodiment shown in Fig. 5 are designated by like reference characters. The second embodiment differs from the first is that (a) the register 108 for storing the machining quadrant for each tool, the register 106 for storing the display

quadrant, and the sign converting unit 109, are provided between the NC data creation unit 102 and the display unit 107; (b) the memory 110 is deleted; and (c) a tape reader 114 is provided and connected to the NC data creation unit 102.

The sign converting unit 109 changes the sign of the X axis if the machining quadrant is the fourth quadrant when the display quadrant is the first quadrant. The resulting data is delivered to the display unit 107 so that all tool paths will be displayed in the first quadrant.

To verify the correctness of an NC tape 113 which has already been created, the NC data is read in from the NC tape 113 by the tape reader 114 and stored in the RAM 104. Next, the quadrant (machining quadrant) corresponding to a tool code is read out of the tool - quadrant memory 105 and set in the register 108. Since the display quadrant is already stored in the register 106, the sign converting unit 109 changes the sign of the NC data, which has been read out of the RAM 104, based on the machining quadrant and display quadrant. The resulting data is delivered to the display unit 107, which responds by displaying, in one and the same quadrant, the tool paths of the first and second tool rests read from the NC tape 113.

In accordance with the present invention as described and illustrated hereinabove, paths traversed by each of a plurality of tools are displayed in one

and the same quadrant on the basis of NC data in the process of being created, or which has already been created. This makes it possible to observe the overall machining contour so that the correctness of NC programming can be ascertained with facility. The invention also permits an already existing program to be checked very easily.

In effecting the display, different colors may be used to represent the different tool paths. This makes it easier to distinguish among the tool paths and, hence, facilitates the program checking operation.

Although the machining quadrants are decided by the tool codes in the description given above, other arrangements are feasible. For example, the machining quadrants can be inserted in the program or entered from an external unit.

As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments thereof except as defined in the appended claims.

CLAIMS:

1. An NC programming apparatus for creating an NC program in accordance with which a workpiece is subjected to machining by each of a plurality of tools in respective quadrants, comprising:

means for creating NC data specifying paths to be traversed by respective ones of the tools in one and the same quadrant;

display means for displaying each of the tool paths in one and the same quadrant on the basis of the created NC data;

quadrant designating means for designating a quadrant to which each tool path actually belongs; and

means for converting the sign of an item of the NC data specifying the tool paths, using the quadrant for which the NC data has been created and a quadrant designated by said quadrant designating means.

2. An NC programming apparatus for creating an NC program in accordance with which a workpiece is subjected to machining by each of a plurality of tools in respective quadrants, comprising:

quadrant designating means for designating a quadrant to which paths traversed by respective ones of the tools actually belong;

means for converting the sign of path data included in created NC data, using a quadrant for which the NC data has been created and a quadrant designated by said quadrant designating means;

means for creating NC data, specifying paths to be traversed by respective ones of the tools in one and the same quadrant, based on an output from said converting means; and

display means for displaying each of the tool paths in one and the same quadrant on the basis of said last-mentioned created NC data.

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Fig. 1

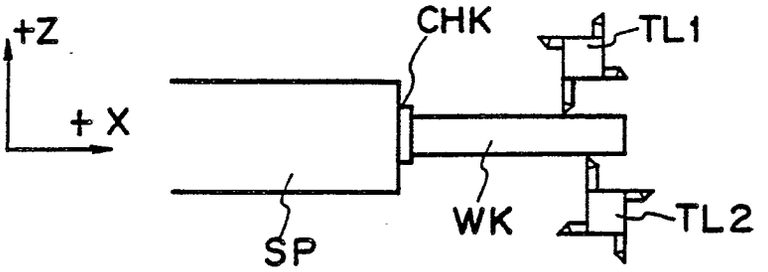


Fig. 2

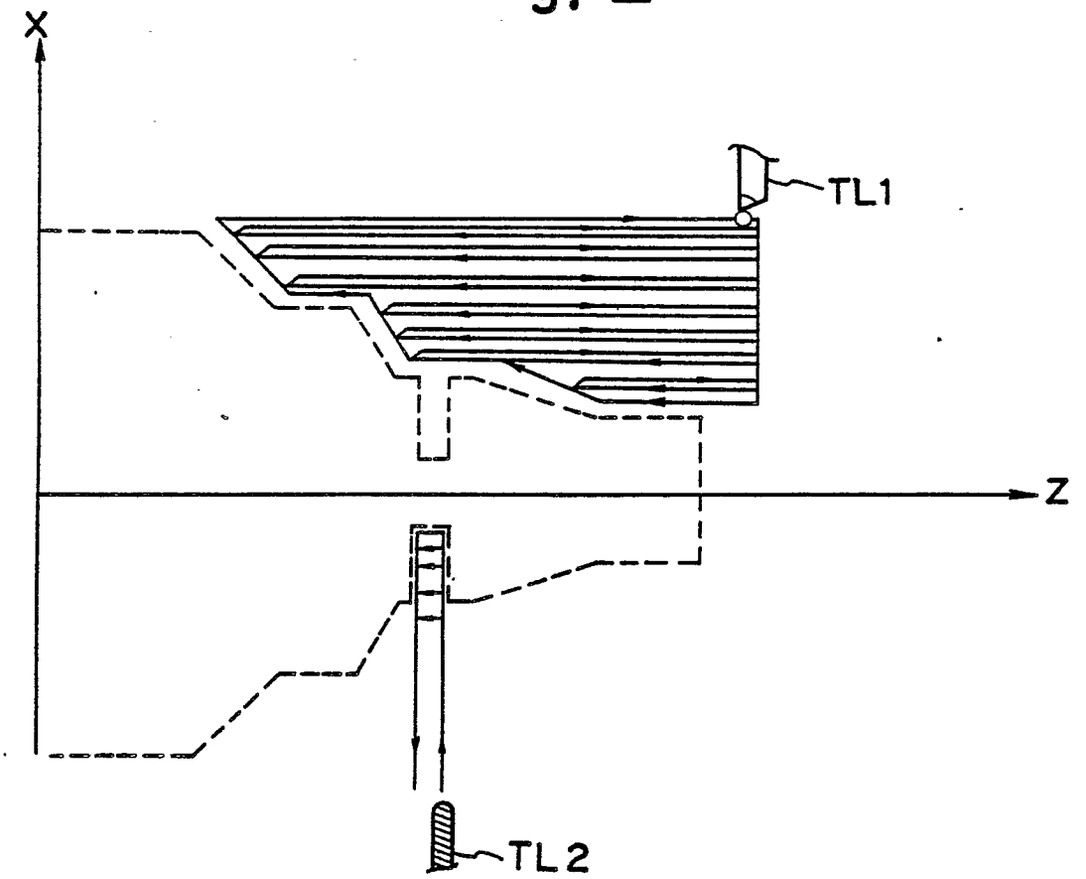


Fig. 3

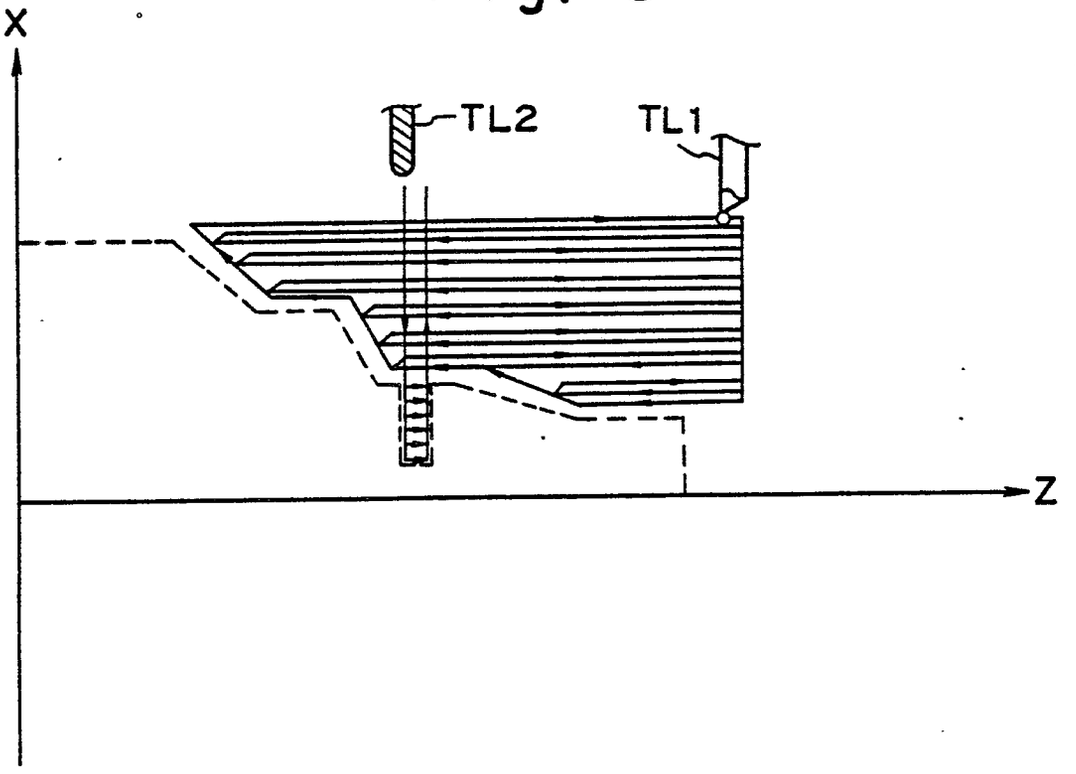


Fig. 4

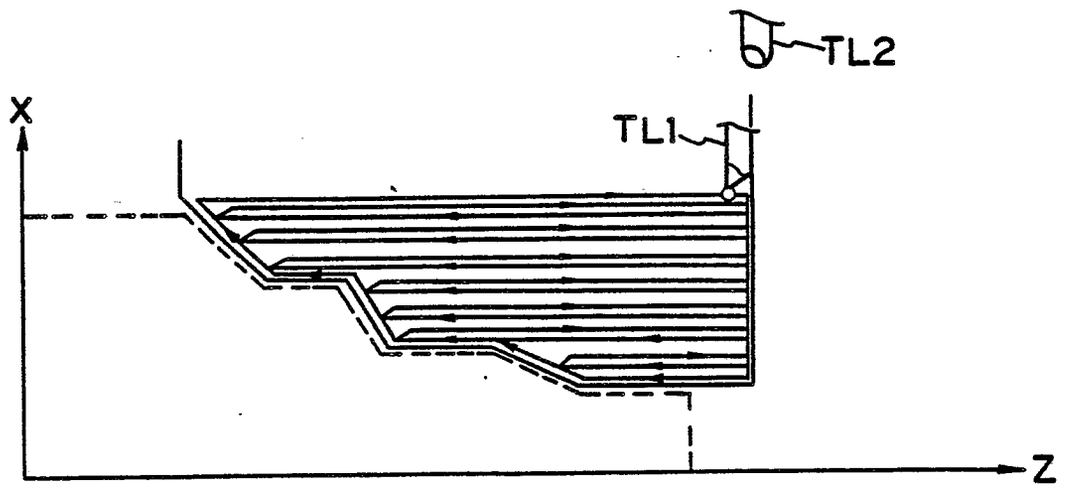


Fig. 5

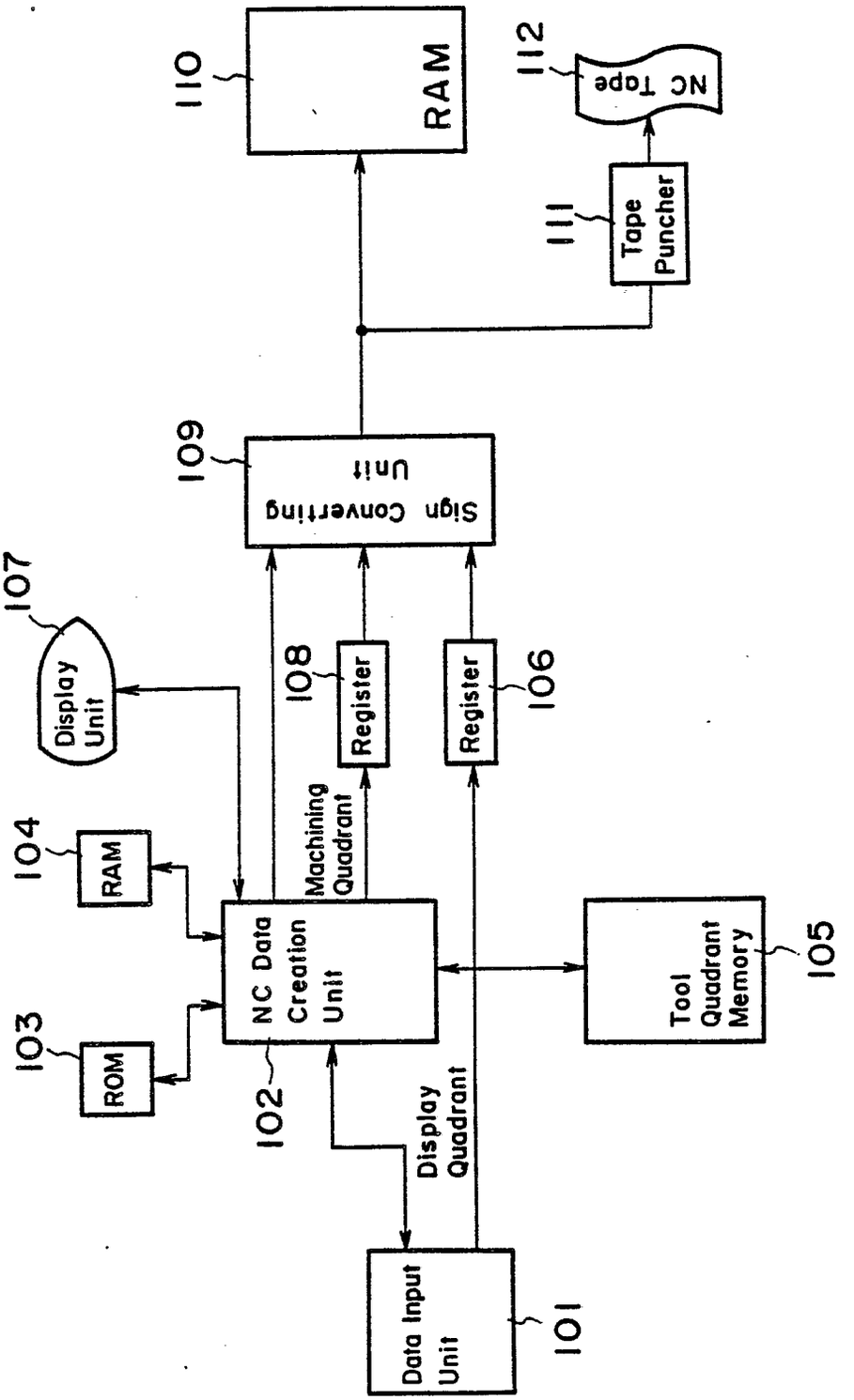
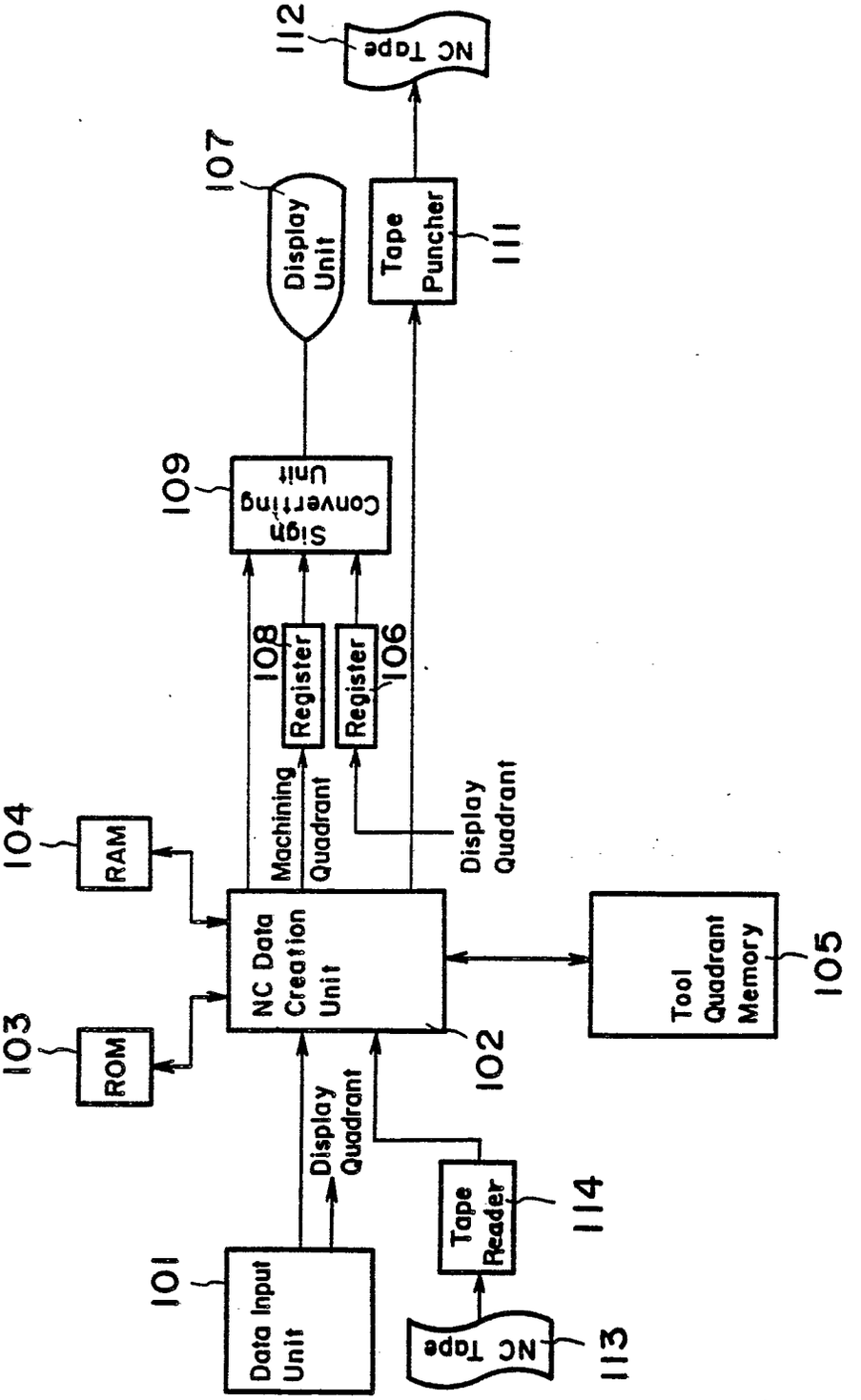

110
RAM
112
NC Tape
111
Tape Puncher
109
Sign Converting Unit
107
Display Unit
108
Register
106
Register
104
RAM
Machining Quadrant
NC Data Creation Unit
Tool Quadrant Memory
105
103
ROM
102
Display Quadrant
Data Input Unit
101

Fig. 6


NC Tape
112
Display Unit
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108
Register
106
Machining Quadrant
Display Quadrant
RAM
104
NC Data Creation Unit
102
Tool Quadrant Memory
105
ROM
103
Display Quadrant
Tape Reader
114
Data Input Unit
101
NC Tape
113